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XXII. *Inquiries into Coloured Light, by a Collation of the Experiments and Observations made by Sir Isaac Newton on that Subject; together with some additional ones. By Governor POWNALL.*

[Concluded from p. 49.]

THE green prismatic tint is supposed to be homogeneous, because consisting of angles of refrangibility in the yellow and in the blue so exactly connected in degree at the point where they coalesce, that no prism nor any succession of prisms have as yet decomposed it. It is, however, in various other instances decomposed; in the circles of colours arising from the refractions of light passing between two lenses, as also in the rings of colours exhibited on bubbles of water. In these instances its constituent parts, which combined form the compound green, emerge as yellow on one side and blue on the other.

Sir Isaac Newton, in *Observ. iv. part 1. book 2.* marking the order of colours in the circles produced by the refraction of light between two lenses, says, "the green was very copious and lively, inclining on one side to blue, on the other to yellow:" and again, in *part ii. book 2. p. 202.* he says, "the green exhibited is principally constituted of *original green*, but not without a mixture of blue and yellow:" again, in *part i. book 2. p. 190.* he says, "then after a lively orange followed an *intense bright* and copious yellow, which was also the best of all the yellows; this changed first to a greenish yellow, then to a greenish blue; but the green between the yellow and the blue was very little and dilute, seeming rather a *greenish white* than a green: the blue which succeeded became very good." In this observation made on the rings of colours on bubbles, notice the increasing intenseness of the light; also successive gradations; also the gradual process of the composition of green and of its decomposition, which is given in the next observation, *p. 189*: "After the red succeeded little or no yellow, but a copious green, which at first inclined a little to yellow, then became a pretty brisk and good *willow-green*, and afterwards changed to a blueish colour; but there succeeded neither blue nor violet." In the first instance, the very little and dilute greenish white, as well as the willow-green in the second, was the dominancy of an intervening white, as will come out hereafter; and in both instances the yellowish green and blueish green mark the compound, partaking on each side of the yellow or of the blue,

blue, as the one or the other predominated in the composition.

But to put this matter out of all doubt, the *fact* comes out on experiment, that when the gradations of the colour take such an arrangement that there is no interfection of the yellow orbicular images with those of the blue, and so no coalescence of these colours, *there is no green.*

Observ. iv. part i. book ii. p. 174. Sir Isaac Newton says, "the colours reckoned in their order from the centre were, black, blue, *white*, yellow, red; here the blue, and yellow not intersecting or coalescing, but separated by an intervening white, there was *no green* in this gradation of colours: if they had approached somewhat near to an interfection of their circles, there might have been, as above, a whitish or willow-green bordered with yellowish and blueish green. The same fact is stated in Observation ix. p. 181: the order of this gradation was, "violet, blue, white, yellow, red." Here again an intervening space of white excludes the existence of green. The same fact of an *intervening white* between the yellows and the blues, excluding the green, comes out in some experiments and observations made by G. W. J.* in addition to those made by Sir Isaac Newton, where, in p. 99. he states, that "diluted purple and blue hues appear completing, with the external yellow and red, and an *intervening white*, these formations of these fringes." I will venture to add, in confirmation of all this, one amongst several observations which I made on these facts. Viewing, through a prism, the solar light as it came through a sash window, and taking the spectrum in the line of refraction as it came from above, the following circumstances appeared:—The frames of the sash were dark, and gradations of colours proceeded from them. The gradations of blue on the upper side; those of the red, orange, yellow, from the lower side. The gradations proceeded from the upper side in this order—deep blue, and, in succession, the several lighter tints or hues of blue till they vanished in the solar light. From the under part they proceeded in this order—deep red, then a brighter, going into orange, and the orange successively brightening into yellow, which melted off into the solar light: no gradations of blue succeeded either order, because there was no going off of light into shade when the spectrum was thus transparent to the solar light; and as there was no blue to intermix with the last yellow, there was *no green*. In proof that this is the reason, it may be observed, that if the light itself

* A very ingenious work published by Cadell 1799.

through

through which the spectrum is viewed, decreases, in any considerable degree of its brightness, there will come on blueish hues, and a very faint intervening greenish one. To try this circumstance more decidedly, I threw up the sash, and made an assistant hold a broad rule, so that I might view the spectrum as it proceeded from the two edges in the same manner as from the frames of the sash: I then directed my assistant to lower the rule down to the bottom of the window, till the yellow in the under gradations intersected the bottom. The yellow of this position not going off into transparent light, but into shade, the blue hues appeared in very decided tints through all their gradations; and where blue, succeeding to the yellow, intersected it, a decided green intervened.

Although no common eye, unpractised in the use and arrangement of colours and their various tints, can discover in the spaces of the prismatic colours called homogeneous, when thrown on an opaque surface, any gradations of tints; yet when these colours are viewed by the prism through an open light so as to be transparent, the gradation of successive tints in each homogeneous space becomes evidently observable to the most common eye. The observer may discern the fact, that no one of those prismatic colours which are called homogeneous is absolutely so, but that, as according to the theorem stated by Sir Isaac Newton himself, they consist of a successive series of innumerable circular or orbicular images of the sun; the tints of the commonly called homogeneous colour, red, vary according to the innumerable succeeding angles of refraction, heightening gradually towards *orange*, and going gradatim into the orange; and that the orange heightens in the same gradual succession of tints going into yellow, and the yellow, in like manner, into pure light: also that the blues of the other gradation of colours are an indiscriminate succession of tints or hues.

Conformably to what is here stated of the heightening of the gradations of the colours at one end of the spectrum into light; of the blues going off, by a like gradation at the other end, into shade or dark; Sir Isaac Newton (*Optics*, book i. prop. v. exper. 16. p. 85.) states, that “the most luminous of the prismatic colours are the orange and the yellow; next the green; and that blue is a faint and dark colour, and the indigo and violet the weakest and darkest of all colours.”

Now from a more decisive examination of the fact by actual experiment we shall be led to see demonstrably that these apparent hues, which are called blue colours, are *not colour*, but a mere modification of light going off into shade, *a partial and successive deprivation of light.*

In

In the first place, it is known by Sir Isaac Newton's experiment, (*Optics*, book ii. part iii. prop. 7. p. 236.) "that blacks are inclined to a blueish colour may be seen from illuminating white paper by light reflected from black substances, for the paper will appear of a *blueish white*."

In considering this observation on a fact as made by Sir Isaac Newton, the method to try the effect of throwing a partial portion of light on a shade occurred to me. I darkened a room partially, letting in a beam of light of five or six inches breadth by opening one of the shutters. I then threw the shade of a ruler, by the intercepted light of a candle, on a sheet of paper: I then held this paper, with this shade so formed on it, in the beam of light. The effect of this portion of daylight thus thrown on the shade of the ruler was, that the shade exhibited a pale but decided blue. As I removed this paper, with this shade of the ruler thus thrown on it, further back from the entrance of the light, but still in the same beam, this blue, without the alteration of any one circumstance but a further deprivation of light, became of a stronger, more decided, deeper blue; and so on gradually as I removed this paper and shade still further back, making a further deprivation of light of a deeper and deeper but decided blue till it went off into a black. This shade, suffering this gradual deprivation of light, exhibited all the gradations called blue which are seen in the prismatic spectrum. Here, then, the fact stands ascertained, that blue is the effect of a partial light, and that a gradual deprivation of light gives all the gradations of blue as they go off into dark.

Mountains and hills, and even unelevated land, in the horizon exhibit, by the going off or deprivation of light, blue tints in the most distant, though such are not the natural tints of these objects; and as these objects suffer more and greater deprivations of light in the evening, or from any other incidental circumstance, these hues go through all the gradations of blue. This any one may see every day; and the painter, if he is an artist, knows how to copy this phænomenon in the arrangement of his colouring.

Another circumstance in the landscape of nature is still further to be observed. As the shade of evening comes on, the blue in the distant horizon not only becomes deeper, but, when the departing light skirts the line of the horizon, this blue, without any change in the state of the refractions, or of the actual colour of the objects, becomes a strong vivid purple. The dark blue of the clouds just above this skirting of departing light, changes in like manner. The rays of the reddish-yellow light and those of this blue coming in coincidence

vidence at the same time to the eye, cause that sensation in the optic nerve.

The sky also, the less that clouds and reflecting vapours are mixed with it, absorbs the light, and gives out only this blue hue, which is a reflection deprived in part of light *: the more clear the sky, the deeper the blue: in the higher regions of the atmosphere this blue becomes of a deep hue going off into dark.

This circumstance takes place and prevails in the chiaro-obscuro of all figures. A true artist knows, that if he would copy the *real fact* in nature, he must tint the going off of light not with gray and black but with gradations of blues, and give a faint suffusion of green in the first going off. Zincke, the famous painter in enamel, understood and copied this fact: he worked an almost insensible green into the blues of the first going off of his lights.

If one may then assume the fact here grounded on the experiments and observations of Sir Isaac Newton, with addition of some further ones on the case as existing in nature, that the gradations of blue are mere effects of the privation of light as it sinks into shade or darkness; and then, from the testimony of the visual senses, which are the only test in the experiments above related, that the gradations of the red even in the prismatic space, wherein it is supposed to be homogeneous, of the orange likewise, and so of the yellow, are only gradual and successive tints of the *one primary colour, red*, heightening, by an innumerable and infinite series of angles of refraction, into a more and more brilliant approximation of pure light, as they purify from the suffusion of colour which they had received in their combination with solar or terrestrial gases and vapours; it will, on this assumption thus grounded on facts, stand demonstrably proved (although I do not venture to announce it but with every diffidence) *that there are not seven, nor three, nor two, but ONLY ONE PRIMARY COLOUR—a compound basis of all the tints of red, orange, and yellow: that green, as an actual and uncompounded primary colour, has no existence: and that the blues are only hues arising from a partial deprivation of light as it goes off into darkness.*

That all the phenomena of colours produced by the re-

* This circumstance, also, makes the difference of the blue of distant parts of the landscape as reflected from valleys and lower parts, or from the higher: the deprivation of light, by its being absorbed by the clearer air in the latter case, gives a deeper blue than that which is reflected from the air hanging over the lower parts. This a true artist, who paints from nature, knows.

fraction of prisms or of lenses, or by thin plates of air or water between lenses made to approach each other, or by the rings on bubbles, or by reflections or inflections of light, may be explained from the facts contained in the above proposition.

All the experiments, observations, and reasoning above, respect only *coloured light*. I dare not venture, on theory, to assert any thing as to the existence of an elementary, pure, uncoloured, uncompounded white light; yet that some such elementary substance exists, combined with one or more of the principles of our atmosphere, and also in combustible and incombustible, and perhaps animal and vegetable substances, seems to be probable; for it can be separated from such in various operations of nature and art.

However, although light may principally exist, combined with caloric and other substances, in a gaseous form, yet it may, and it is very generally admitted, that it does also exist, independent of caloric, in solid bodies and fluids of various kinds; and heat, it cannot be denied, exists sensibly in both combustible and incombustible bodies which exhibit no visible light. Indeed, that light and heat are two distinct existing principles is now finally and demonstrably ascertained and proved by Dr. Herschel's curious experiments of the fact, showing that heat as well as light are each liable to different and peculiar refractions, by which they are separated from each other, and take a separate and distinct existence in different space.

Quod restat desideratum est.

XXIII. *History of Astronomy for the Year 1801.* By
JEROME LALANDE.

THE commencement of the 19th century was distinguished by an astronomical event, the discovery of a planet at Palermo in Sicily, by M. Piazzi, on the 1st of January*. It was as small as a star of the 8th magnitude: he observed it during forty days. The observations he sent me arrived too late for us to be able to follow it, and we were obliged to calculate its orbit from his own observations alone. Burckhardt, Olbers, Bode, Piazzi, and Gauss, have found that to represent these observations it is necessary to suppose that

* I here employ the calendar of all nations, being persuaded that the French government will soon renounce the new calendar, which is not understood, and cannot be adopted either by our neighbours or by the majority of the French themselves.—L.